TOPIC 04 – BONDING
4.3 – INTERMOLECULAR FORCES

IB Chemistry

T04D05

Mr. Martin Brakke

Intermolecular Forces – 2 hrs

- 4.3.1 Describe the types of intermolecular forces (attractions between molecules that have temporary dipoles, permanent dipoles or hydrogen bonding) and explain how they arise from the structural features of molecules. (3)
- 4.3.2 Describe and explain how intermolecular forces affect the boiling points of substances. (3)

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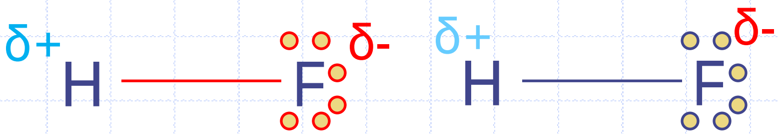
Types of Forces

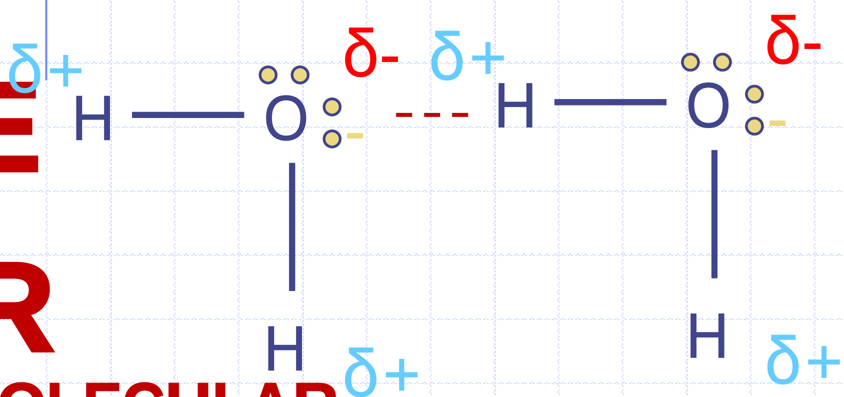
INTER MOLECULAR FORCES

Weak Forces:

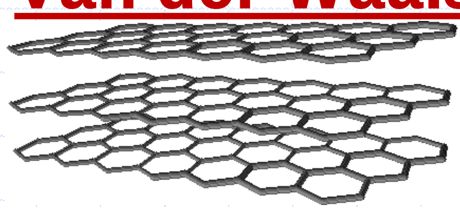
Dipole / Dipole



Hydrogen Bonding



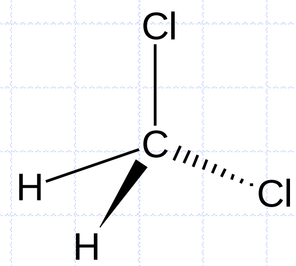
Van der Waals

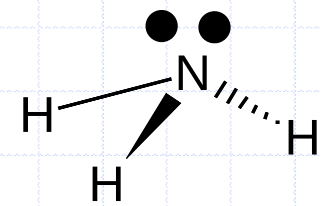


INTRA MOLECULAR FORCES

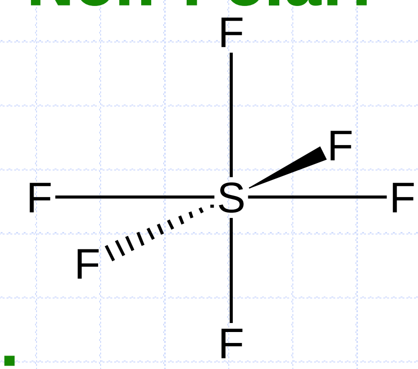
Covalent / Molecular:

Polar:

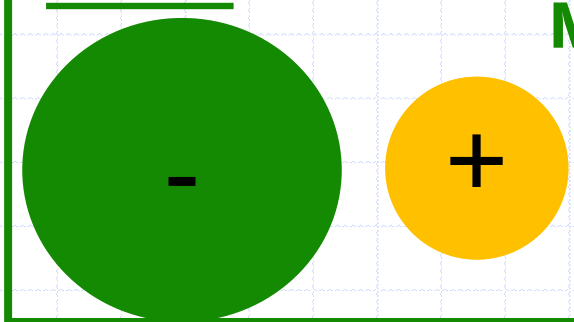




Non-Polar:



Ionic:



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Types of Intermolecular Forces

4.3.1 Describe the types of intermolecular forces (attractions between molecules that have temporary dipoles, permanent dipoles or hydrogen bonding) and explain how they arise from the structural features of molecules. (3)

- **Van der Waals'** forces are known as short-range attractive forces caused by the temporary dipole and random fluctuations in electron density in a molecule or an atom
  - Over an averaged period of time, electron density is spread evenly around the nucleus
  - At a given instant, electron density distribution may be asymmetrical giving the atom or molecule a temporary dipole
  - A **dipole** is a separation of charge in which there are opposite poles [di(2) poles(opposites)]

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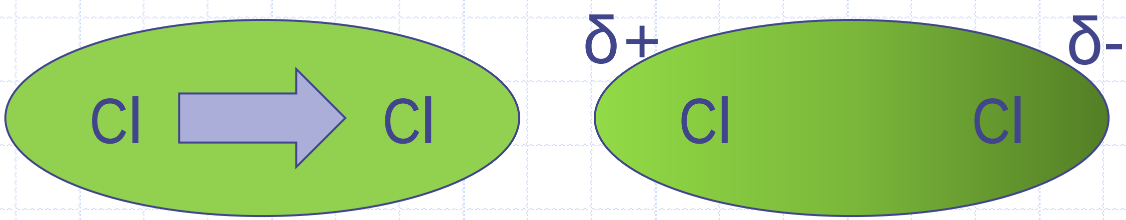
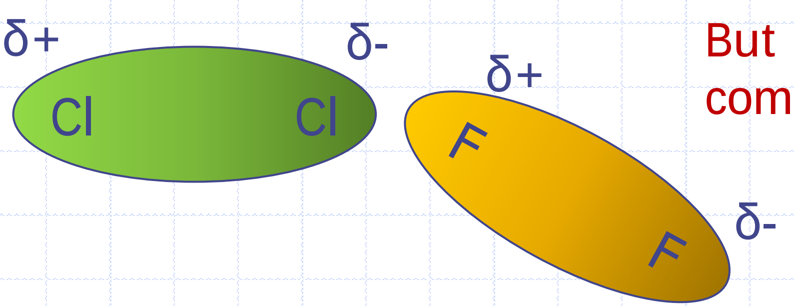
Van der Waals are Temporary

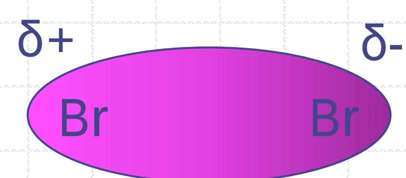
- When a neutral molecule (left) has an uneven electron density at any given time, **momentary** (or temporary) **dipoles** are created



- When another neutral molecule is in the presence of a temporary dipole (or a polar molecule or ion), it causes an **induced dipole**

It will continue to have a chain effect but will quickly return to it's original state. But not before it has already attracted compounds toward one another





Factors that affect Van der Waals

- Van der Waals’ forces are influenced by
  - Molecular size
  - Molecular Shape
- As molecules increase in size they have **more electrons** and those electrons are located **further from the nucleus** and therefore are **less strongly attracted**.
  - This simply means that large molecules are more easily polarizable (forming an induced dipole).
  - This results in stronger and more elaborate Van der Waals forces

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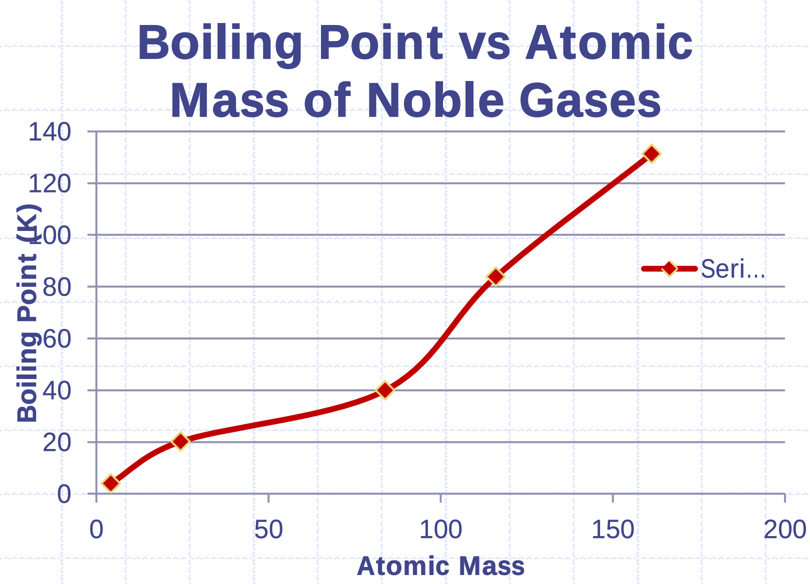
Effect of Size on Van der Waals

- As mentioned, the boiling point and melting point of halogens and nobles gases increases due to increased VDW

Molecule	Boiling Point / K	Molecular Mass g / mol
F_2	85	38
Cl_2	239	71
Br_2	332	160

Element	Boiling Point / K	Relative Atomic Mass g / mol
He	4.2	4.00
Ne	24.5	20.18
Ar	83.9	39.95
Kr	116.0	83.80
Xe	161.3	131.29



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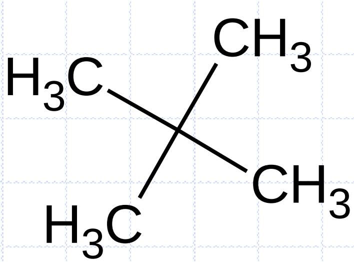
Effect of Molecular Shape

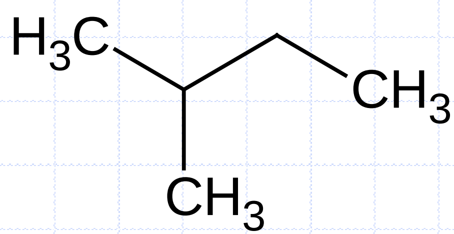
- Molecules with large surface area allow a closer contact between molecules increasing Van der Waals' forces
- In comparing the relative strengths of intermolecular forces:
  - When molecules have VERY difference molecular masses, the effect of increased Van der Waals' forces is greater than dipole-dipole interactions and the largest has the strongest attraction.
  - When molecules have SIMILAR molecular masses, dipole-dipole forces are more significant and the most polar has the strongest interaction.

Shape/Branching and Van der Waals'

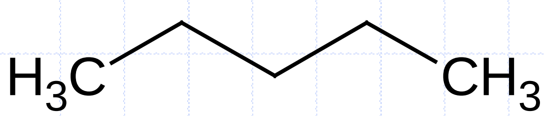
- More branched molecules (on the left) have less surface area and are therefore less compact
- Less branched molecules (on the right) are able to pack more closely with greater surface area and are therefore able to have increased Van der Waals forces and increased boiling points



BP 283 K



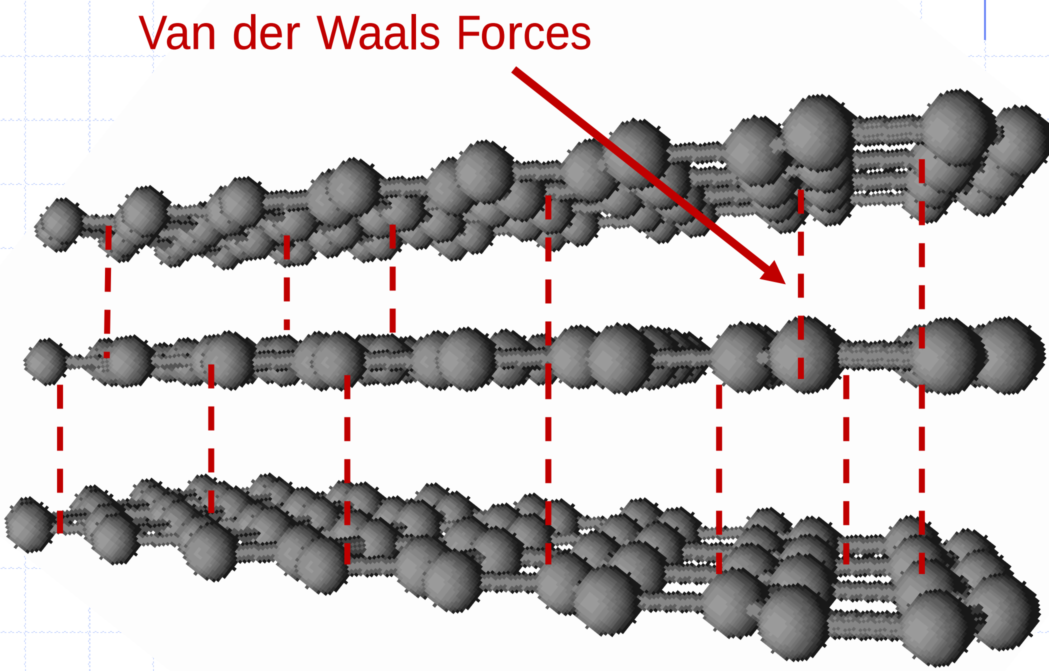
BP 301 K



BP 309 K

Example of Van der Waals - Graphite

- Since graphite is so large, individual sheets can easily have induced or momentary dipoles
  - **Large mass**
  - **Large surface area**
- When this occurs, each sheet attracts itself to another
- These sheets can be easily (relatively) broken apart



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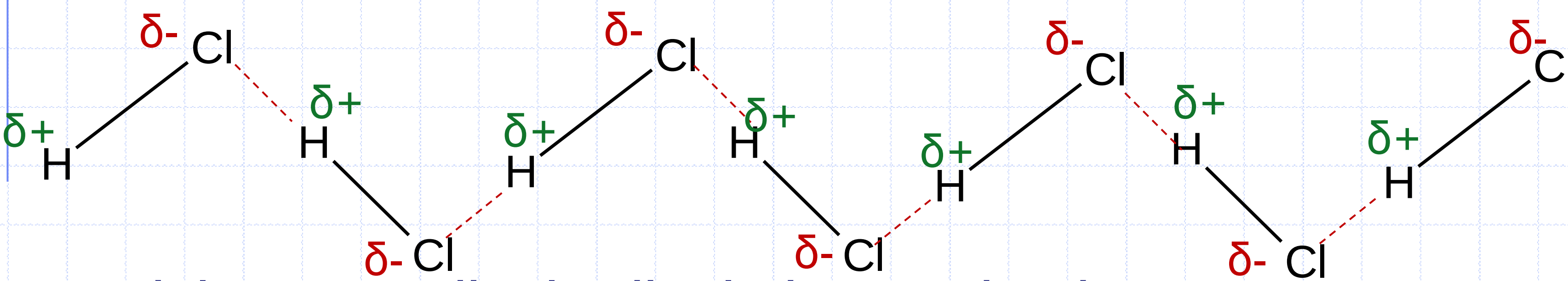
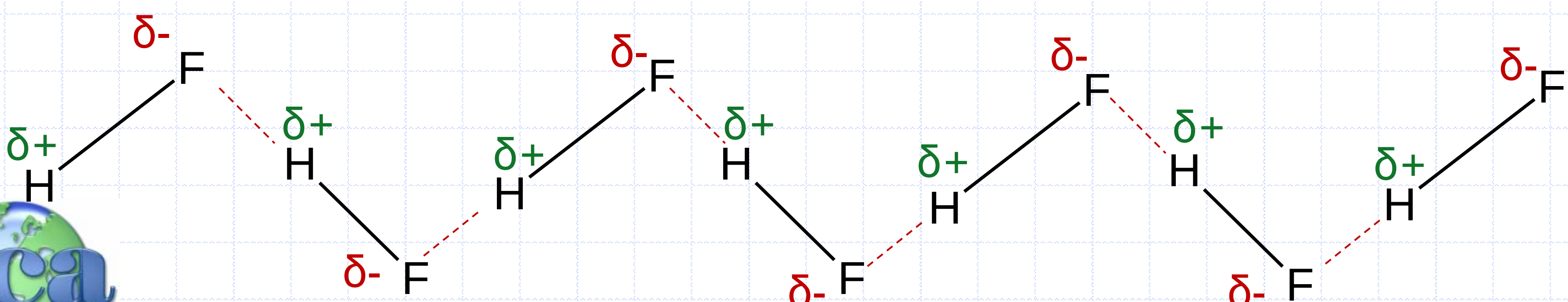
Dipole-dipole Interactions

- Dipole/Dipole forces occur when polar molecule with permanent polarity attracts opposite sides of nearby molecules (partial positive to partial negative)
- Generic Dipole-dipole interaction in H-Cl



- “Special” strong dipole-dipole interaction in H-F



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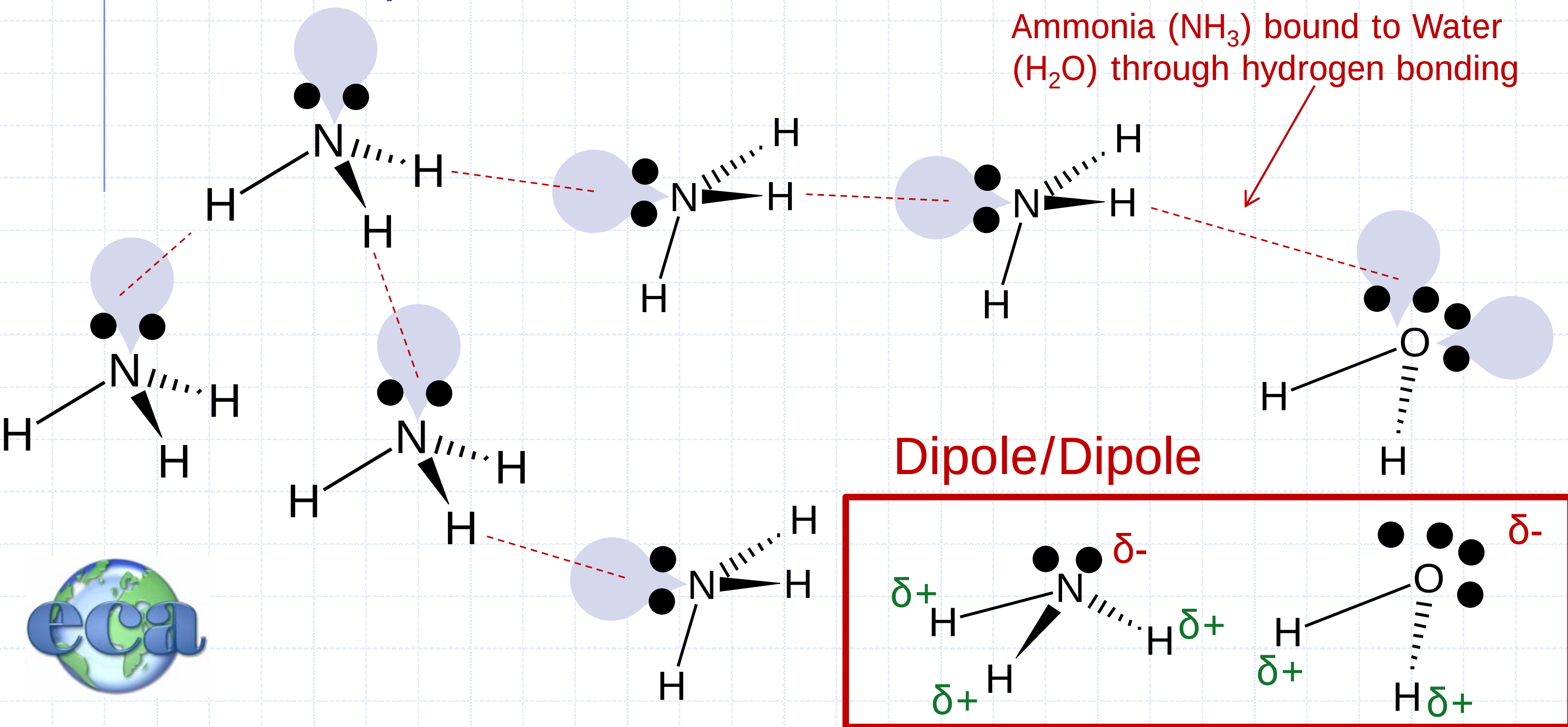
Hydrogen Bonding

- Hydrogen bonding is a STRONG type of Dipole/Dipole interaction where an N, O, or F-bound Hydrogen is attracted to the lone pair on either N, O, or F



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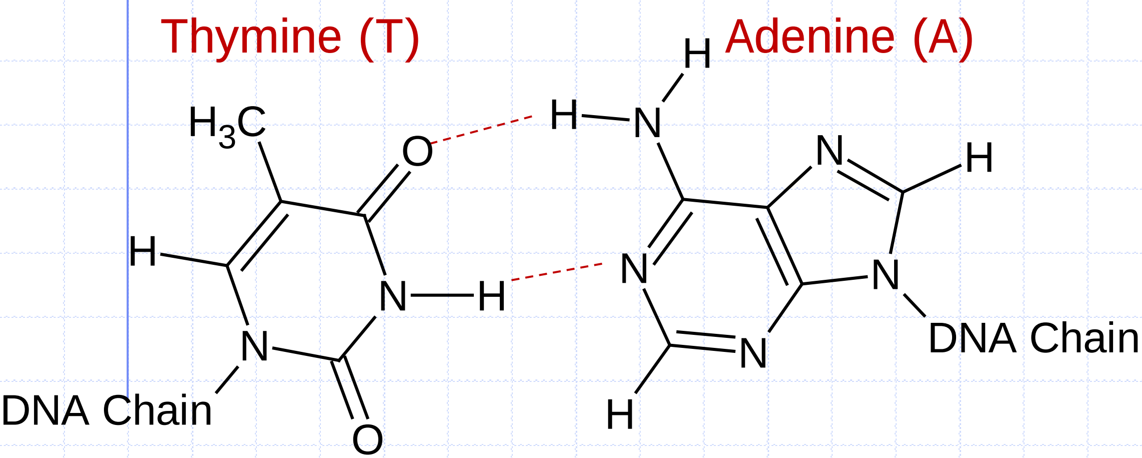
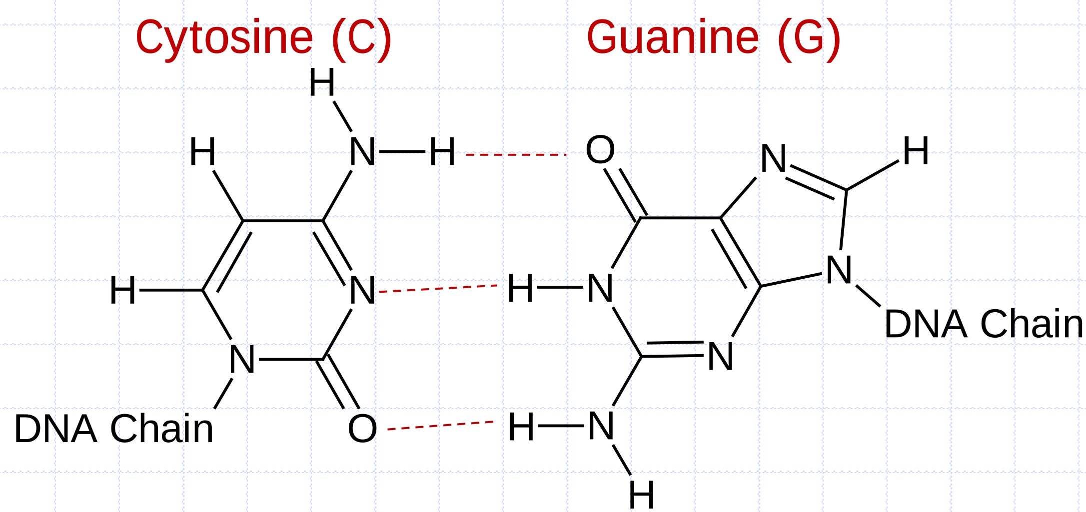
Hydrogen Bonding in DNA



- In DNA, T's and A's combine as C's and G's combine, both through hydrogen bonding
- The chain is held by peptide bonds



Effect of Forces on Physical Props

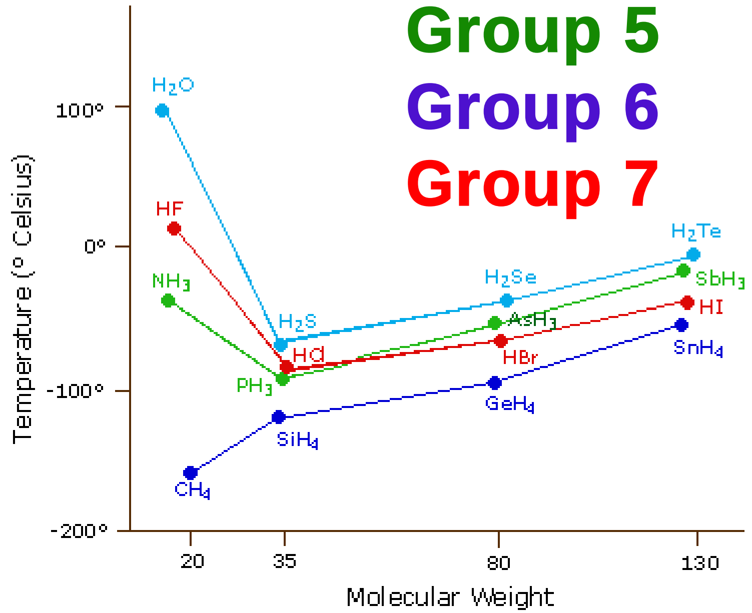
4.3.2 Describe and explain how intermolecular forces affect the boiling points of substances. (3)

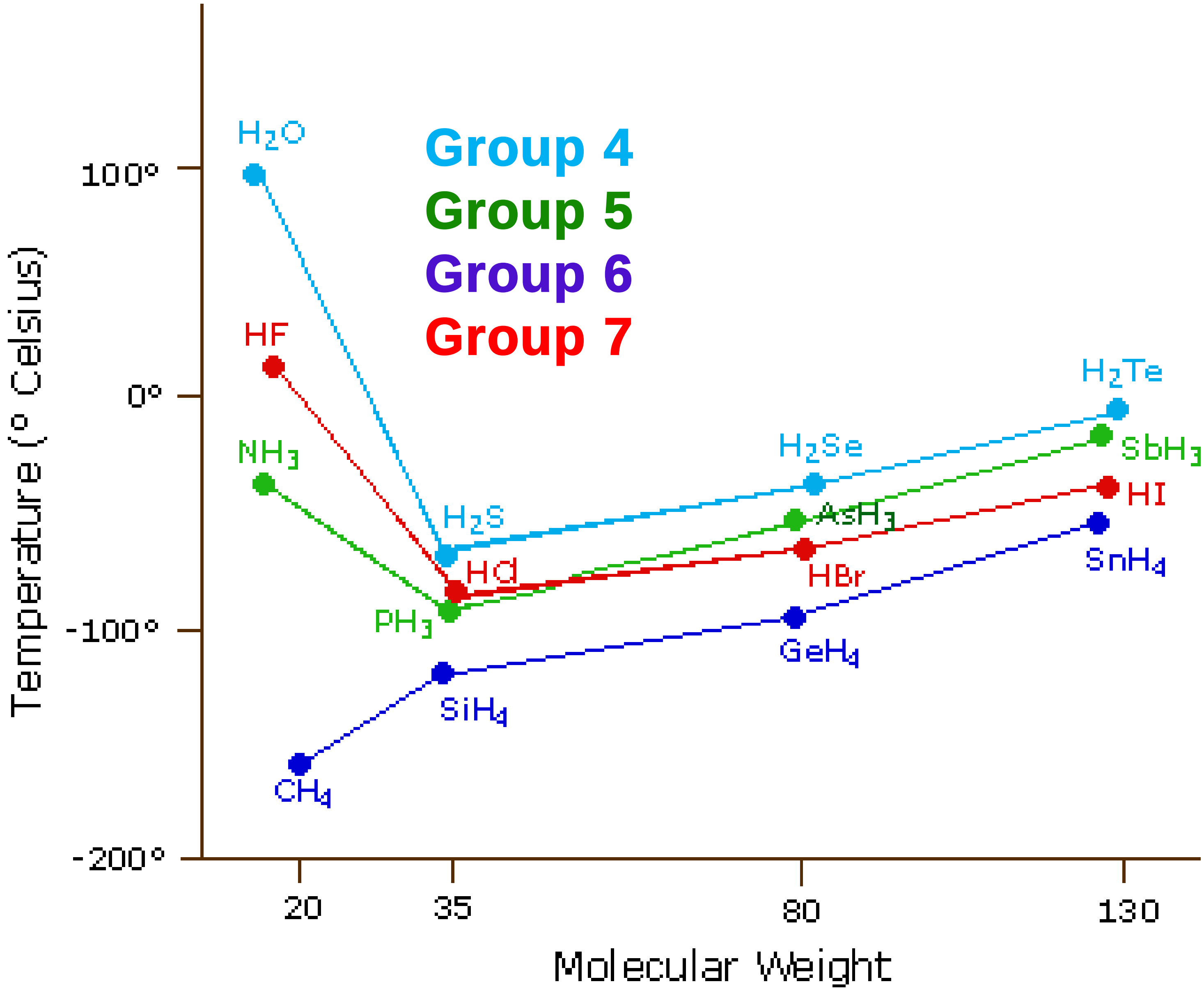
- Hydrogen bonding affects
  - The boiling points of H_2O, NH_3, HF, and other molecules
  - The solubility of simple covalent molecules
  - The density of water and ice
  - The viscosity of liquids such as alcohols

Trends:

- Group 4 elements: "normal" behavior due to increase Van der Waals
- Groups 5 – 7 follow the same trend with the exceptions of:
  - HF, H_2O, and NH_3 are increased due to hydrogen bonding

Group 4
Group 5
Group 6
Group 7




Group 4
Group 5
Group 6
Group 7
100°
0°
-100°
-200°
Temperature (° Celsius)
H2O
HF
NH3
H2S
HCl
PH3
SiH4
CH4
H2Se
AsH3
HBr
GeH4
H2Te
SbH3
HI
SnH4
20
35
80
130
Molecular Weight